The effect of explosive remnants of war on global public health: a systematic mixed-studies review using narrative synthesis

Alexandra Frost, Peter Boyle, Philippe Autier, Colin King, Wim Zwijnenburg, David Hewitson, Richard Sullivan

Summary

Background Explosive remnants of war (ERW)—landmines, unexploded ordnance (UXO), and abandoned explosive ordnance (AXO)—have been recognised as a threat to health since the 1990s. We aimed to study the effect of ERW on global public health.

Methods In this systematic mixed-studies review, we searched the Web of Science, Scopus, PubMed, and ProQuest databases, and hand searched relevant websites, for articles published between Jan 1, 1990, and Aug 31, 2015. We used keywords and Medical Subject Headings related to ERW, landmines, UXO, and AXO to locate original peer-reviewed quantitative, qualitative, or mixed-methods studies in English of the direct physical or psychological effects of ERW on direct victims of the explosive device or reverberating social and economic effects on direct victims and indirect victims (their families and the wider at-risk community). We excluded studies if more than 20% of participants were military, if they were of deminers, if they were from high-income countries, or if they were of chemical weapons. We identified no peer-reviewed studies of AXO effects, so we extended the search to include grey literature. We critically appraised study quality using a mixed methods appraisal tool. We used a narrative synthesis approach to categorise and synthesise the literature. We extracted quantitative data and calculated means and percentages.

Findings The initial search identified 10 226 studies, leaving 8378 (82%) after removal of duplicates, of which we reviewed 54 (26 [48%] were quantitative descriptive studies, 20 [37%] were quantitative non-randomised studies, four [7%] were mixed-methods studies, and four [7%] were grey literature). The direct psychological effects of landmines or UXO appear high. We identified comorbidity of anxiety and depression in landmine or UXO victims in four studies, more women presented with post-traumatic stress disorder than did men in two studies, and landmine or UXO victims reported a greater prevalence of post-traumatic stress disorder, anxiety, or depression than did control groups in two studies. Overall injury and mortality rates caused by landmines or UXO decreased over time across five studies and increased in one. More men were injured or killed by landmines or UXO than were women (0–30·6% of women), the mean ages of casualties ranged from 18·5 years to 38·1 years, and victims were likely to be doing an activity of economic necessity at the time of injury. The proportion of casualties of landmines or UXO younger than 18 years ranged from 22% to 55% across twelve studies. Landmine or UXO victims who had one or more limbs amputated ranged from 19·5% to 82·6%. Landmines and UXO had a negative effect on internally displaced populations and returning refugees, physical security, economic productivity, child health and educational attainment, food security, and agriculture in studies from seven countries. We could not establish the proportion of casualties caused by AXO from unplanned explosions at munitions sites, although the grey literature suggests that AXO is a substantial problem.

Interpretation Individually, these landmine and UXO results are not new and substantiate findings from existing research. Taken together, however, these findings provide a picture of the effect of landmines and UXO that stretches far beyond injury and mortality prevalence, making landmine and UXO clearance a more favourable option for funders. AXO effects are understudied and warrant further research.

Funding King's College London.

Lancet Public Health 2017; 2: e286–96

Published Online May 18, 2017 http://dx.doi.org/10.1016/S2468-2667(17)30099-3

See Comment page e254

Conflict and Health Research Group, King's College London, London, UK, and King's Centre for Global Health, King's Health Partners and King's College London, London, UK (A Frost MSc, Prof R Sullivan MD); **Institute of Cancer Policy, King's Health Partners Comprehensive Cancer Centre, London, UK** (Prof R Sullivan); **International Prevention Research Institute, Lyon, France, and University of Strathclyde Institute of Global Public Health at the International Prevention Research Institute, Lyon, France** (Prof P Boyle PhD, Prof P Autier MD); **Fenix Insight, Copthorne, West Sussex, UK** (C King, D Hewitson); **and PAX, Utrecht, Netherlands** (W Zwijnenburg MA)

Correspondence to: Alexandra Frost, King's Centre for Global Health, King's Health Partners and King's College London, London SE5 9EJ, UK **alexandra.frost@kcl.ac.uk**

Introduction

The effects of explosive remnants of war (ERW), defined here as landmines (victim-activated explosive traps that target people and vehicles), unexploded ordnance (UXO; explosives that have been fired, dropped, launched, or projected during a conflict yet remain unexploded), and abandoned explosive ordnance (AXO; explosives that have not been used or have been left behind or dumped by a party in an armed conflict and are no longer under the control of the party that left them behind or dumped them), are disproportionately borne by citizens of low-income and middle-income countries (LMICs).[1] ERW pose a threat to people's health and human rights in more than 60 LMICs.[2,3] Annual casualty numbers are

Research in context

Evidence before this study

We did a systematic review to find previous systematic reviews completed before June 30, 2015. We did searches by combining keywords and Medical Subject Headings related to "explosive remnants of war" and "health", with no language restrictions. We searched the Cochrane Library, Web of Science, Scopus, PubMed, Google Scholar, and ProQuest and located 977 records, of which three were systematic reviews. These systematic reviews were small: two single-country studies and one two-country study. None of the reviews examined abandoned explosive ordnance (AXO) effects; the most relevant touched on the economic and social effects of landmines or unexploded ordnance (UXO) in Laos and Cambodia. The authors were unable to estimate national injury prevalences, but did categorise injuries and mortalities according to dependent factors, such as sex, age, and landmine or UXO device type. In another review, 1400 mortalities due to landmines or UXO were recorded in Iran after the conflict (1988 and 2003) compared with 188 015–217 489 deaths during the conflict (1980–88). A final review of injuries among Afghan refugees attributed 33% of injuries to landmines compared with 33% to shrapnel and 27% to firearms. Little to no information was provided about reverberating effects in any of the studies.

Added value of this study

In this study, we broadened the scope from the existing systematic reviews, including studies from 22 low-income and middle-income countries. Unlike previous reviews, we included studies of the direct psychological effects of landmines or UXO. Building on the previous reviews, we provided evidence of direct physical effects according to sex, age, explosive remnants of war device type, injury type, and activity at the time of injury. Most casualties of landmines or UXO are men in the economically active age range (15–64 years). Children also constitute a substantial proportion of casualties of landmines or UXO (22–55%). Post-traumatic stress disorder, anxiety, and depression were also seen in landmine or UXO victims. When considering reverberating effects we found that landmine or UXO contamination negatively affects socioeconomic development, food security, and child health and educational attainment. We established from the grey literature that AXO effects are understudied and explosions have the potential to inflict injuries on civilians on a large scale.

Implications of all the available evidence

The included studies show the breadth of effects of explosive remnants of war. From a public health perspective, landmine and UXO clearance has important synergistic gains, not only in the reduction of morbidity and mortality, but also in improved socioeconomic outcomes for affected communities. The effects of AXO require further research to understand and quantify the magnitude of the problem.

falling, from 9220 casualties in 1999 to 6461 in 2015,[2] thanks to the widely ratified 1997 Mine Ban Treaty[4] and continuing commitment from the international community. ERW casualties are usually maimed rather than killed and although the exact number of survivors is unknown, from 1999 to 2015, 72 739 people were injured by ERW but survived, many with subsequent long-term psychological and physical sequelae.[2] Additionally, the wider long-term effects of ERW (referred to in this study as reverberating effects) are a social and economic burden to victims, their families, the wider at-risk community, and health systems.[5] Despite their importance, these effects have not been systematically examined on a global scale before.

See Online for appendix

Previous systematic reviews[6–8] have focused on the incidence and prevalence of injuries and mortalities due to ERW in a small number of settings. They neglected the psychological effects on victims and the reverberating socioeconomic effects on the victims' families and wider communities. This study will synthesise the existing evidence from quantitative and mixed-methods studies as well as grey literature. We aim to compare the direct (physical and psychological) and reverberating (social and economic) effects of exposure to landmines, UXO, and AXO on affected people in LMICs, analysing their effect on global public health.

Methods

Search strategy and selection criteria

In this systematic mixed-methods review, we searched for original peer-reviewed quantitative, qualitative, and mixed-methods studies of the direct physical or psychological effects or reverberating social and economic effects of ERW. As we could not find any peer-reviewed studies of AXO effects, we searched grey literature for this type of ERW. Detailed inclusion and exclusion criteria to assess eligibility were agreed by two authors (RS and AF) with expert guidance from a third (CK; appendix). We only included articles written in English, published between Jan 1, 1990, and Aug 31, 2015. We limited the publication date to 1990 when ERW contamination was first recognised as a humanitarian issue after the widespread use of landmines during conflicts in the 1980s and early 1990s, prompting the establishment of the International Campaign to Ban Landmines in 1992.[9] Participants of identified studies were direct victims of ERW or indirect victims (ie, their families and the wider at-risk community, defined as those living on ERW-contaminated land in LMICs). The focus of this review is on civilians, so we excluded deminers. We decided to include articles for which up to 20% of participants were in the military. This decision reflects the setting of

the studies and the type of conflicts that occur in these settings where the line between civilian and combatant is often blurred. For a study to guarantee that any of the civilian participants did not sustain their injuries during combat is difficult. We also excluded studies if they were from high-income countries or of chemical weapons. ERW encompasses landmines, UXO, and AXO, and for clarity we will differentiate between them throughout the report (definitions are given in the appendix [pp 1–2]).

In September, 2015, we searched the Web of Science, Scopus, PubMed, and ProQuest databases and hand searched relevant websites (details of the search strategy for the Web of Science are given in the appendix [p 2]). We used comprehensive search terms derived from the International Campaign to Ban Landmines and Small Arms Survey: ("explosive remnants of war" OR "unexploded ordnance" OR "abandoned ordnance" OR "cluster munition*" OR "landmine*" OR "unplanned explosion*" OR "weapon stockpile*") OR ([unexploded OR abandoned] AND [shells OR grenades OR mortars OR rockets OR air-dropped bombs OR explosives]). We searched Google and relevant websites such as the Small Arms Survey, Human Rights Watch, and Eldis for publications related to AXO. After the initial search, we uploaded titles into Evidence for Policy and Practice Information Reviewer 4, removed duplicates, and then screened titles and full texts to categorise the studies. AF did the literature search in discussion with RS, and disagreements over study inclusion were resolved in consultation with CK and DH.

Data analysis

AF extracted data from the included studies in discussion with RS. We extracted the following information from the included studies: title, journal title, year, setting, age range of participants, sample size, sampling method, type of exposure (landmines, UXO, or AXO), survey type, survey year, methods, outcomes (direct or reverberating effects), study type, and statement of strengths and weaknesses. We used a simple scoring system with methodological quality criteria for the appraisal to account for the distinct ontological and epistemological differences between studies.[10] We scored the included articles using a mixed methods appraisal tool to assess study quality.[11]

We then applied the narrative synthesis approach to the included studies. This approach to the systematic review and synthesis of findings from multiple studies relies on use of words to summarise and explain the findings from studies with methodological heterogeneity.[12] We did the thematic analysis using Nvivo: we coded the data according to topics and used the text search to provide detail. We extracted quantitative data and entered it into Microsoft Excel and then did simple analysis, calculating means and percentages.

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

The initial search identified 10 226 studies, and after removal of duplicates, we screened the titles and abstracts of 8378 (82%; figure). 211 (2%) studies remained for full-text screening and we included 54 (1%)[13–66] in the systematic review. The included studies were set in 22 countries across Africa, Asia, and Europe from 1960 onwards. The peer-reviewed studies were most often quantitative descriptive studies (26 [48%] studies, of which 16 [30%] were hospital based or clinic based), followed by quantitative non-randomised studies (20 [37%]) and mixed-methods studies (four [7%]). Four (7%) additional studies were grey literature studies. Table 1 lists the characteristics of the included studies by effect and exposure.

We assessed studies for risk of bias. 19 (35%) studies had methodological deficiencies, consisting of insufficient explanation of data collection or analysis, absence of sampling strategy, an unrepresentative sample, inadequate explanation of how the sample size was derived, incomplete information about the control

For the **International Campaign to Ban Landmines website** see http://www.icbl.org

For the **Small Arms Survey website** see http://www.smallarmssurvey.org

For the **Human Rights Watch website** see https://www.hrw.org

For the **Eldis website** see http://www.eldis.org

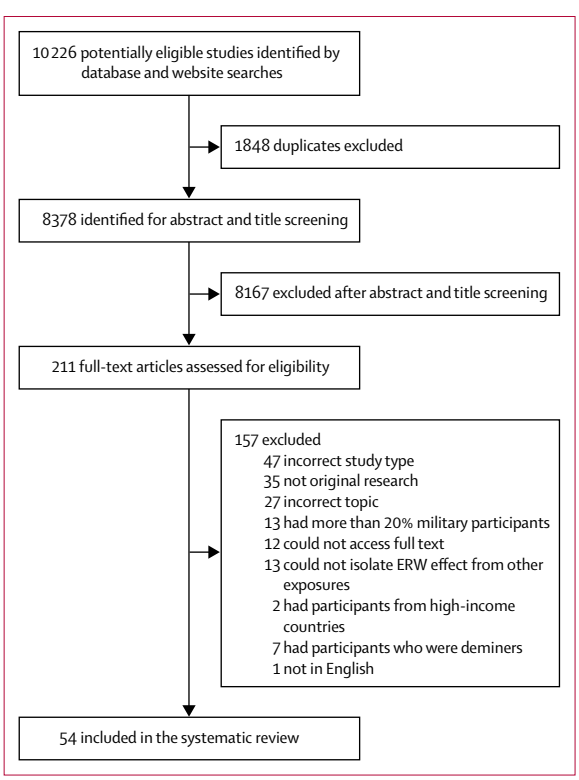

Figure: **Study selection**
ERW=explosive remnants of war.

	Studies (n=54)
Effects	
Direct effects	37 (69%)
Psychological effects*	6 (11%)
Physical effects	38 (70%)
Injury and mortality rates	6 (11%)
Sex of victims	27 (50%)
Age of victims	17 (31%)
Activities at time of injury	10 (19%)
Case fatalities	21 (39%)
Amputations	17 (31%)
Pain	3 (6%)
Blindness	7 (13%)
Reverberating effects	16 (30%)
Effects on displaced populations and returning refugees	4 (7%)
Cost-benefits of mine clearance	7 (13%)
Socioeconomic effects	5 (9%)
Exposure	
AXO	4 (7%)
Landmines	31 (57%)
UXO	7 (13%)
Landmines and UXO	12 (22%)

Data are n (%). AXO=abandoned explosive ordnance. UXO=unexploded ordnance. *Post-traumatic stress disorder, anxiety, and depression.

Table 1: **Characteristics of the included studies**

group, absence of justification of measurements, and absence of standardised instruments for measurement (table 2).

Post-traumatic stress disorder was more prevalent in the group injured by landmines or UXO (10%) than in the non-injured group (4%) in one study[62] in Laos (table 3). Post-traumatic stress disorder prevalence in landmine or UXO victims was 73·0% in one study[30] and 100% in another,[29] both in Lebanon. More women presented with post-traumatic stress disorder than did men in studies in Laos[62] and Sri Lanka.[32] Comorbidity of anxiety and depression was identified in four studies.[16,29,32,66] Anxiety and depression prevalence was 71–82%.[16,29,32,66] Anxiety or depression was more prevalent in the group with a disability caused by landmines or UXO (82%) than in the group with a disabilty not caused by landmines or UXO (79%) in one study in Laos.[66]

Injury and mortality rates were calculated in Chechnya,[20] Afghanistan,[21,22] Eritrea,[33] Kurdistan,[36] and eastern Burma.[44] Retrospective and prospective surveillance data were collected using clinic-based and community-based questionnaires and surveys. An overall decrease occurred in injury and mortality rates caused by landmines or UXO across five studies[20,22,33,36,44] and an overall increase occurred in one.[21] On closer examination, injury and mortality rates fluctuated within studies. For example, in Chechnya, injury rates rose and fell across the two phases (1994–96 and 1999–2009) of the Chechen conflict (1995: 2·3 injuries per 10 000 people; 2000: 6·6 injuries per 10 000 people; 2002: 4·0 injuries per 10 000 people).[20] In Afghanistan, the start of the conflict between Taliban and Coalition forces in October, 2001, saw injuries per month rise from 20–40 in October, 2001, to 160–180 in January, 2002, before falling again.[22]

More men were injured or killed by landmines or UXO than were women (0–30·6% women) (appendix pp 5–6).[13,16,19–22,25,28–30,33,36,38,41,42,46,50,51,53,55,56,58,60–62,63,65] The mean ages of casualties (range 18·5 years to 38·1 years) in all included studies falls into the economically productive age range (15–64 years).[16,17,25,28,30,33,38,46,50,53,57,55–59,61–63] This finding matches with the type of activity that the victim was doing at the time of injury and the economic effect on victims and their families. Ten studies[19,20,22,25,36,50,56,60,61,63] provided data for the types of activities being done at the time of injury (table 4). Economically productive activities—farming and grazing livestock—had the highest prevalence at the time of injury by landmines or UXO in seven studies[20,22,25,50,56,60,61] (23·7–46·9% of victims).

Scrap metal collection from UXO-contaminated forests was only worthwhile for the poorest households surveyed in Vietnam; those with better options for income generation felt that the time and risks outweighed the returns.[23] Injuries caused when the victim was tampering with or handling the device tended to be from UXO (72·0% of injuries due to UXO *vs* 10·4% due to landmines in Chechnya;[20] 14·9% *vs* 1·6% in Afghanistan[63]). In a study[55] from Laos, a third of casualties occurred when the victim played or tampered with UXO, even though they knew that it was an explosive device. Conversely, a Nepalese study[19] reported that only one (1%) individual of 118 injured while handling or tampering with the explosive device was aware that this activity was dangerous.

Case fatality ratios for those injured by landmines or UXO ranged from 2·1% to 80% (appendix p 7).[13,14,17,19,20,22,28,36,43,50,51,58,59,60] Case fatality ratios for hospital-based studies ranged from 2·1% to 25·0%. Absence of prehospital care for landmine or UXO victims was identified as a contributing factor to fatality ratios in four studies.[19,60,63,50] One study[63] found that landmine or UXO victims in Afghanistan who did not receive care at a health facility were more likely to die from their injuries, be female, and be unemployed than those who did receive care. Landmine victims in rural Iran waited between 15 min and 24 h from time of accident to admission to a health facility.[60] Four studies[17,19,22,63] reported higher case fatality ratios for children injured by landmines or UXO than for adults, whereas two[20,51] reported higher case fatality ratios for adults than for children (appendix p 8). The proportion of casualties of landmines or UXO younger than 18 years ranged from 22% to 55% across twelve studies;[17,19–21,28,29,36,51,58,60–62] three studies[13,22,33] only provided data for those younger

	Monitoring period	Setting	Sample size	Exposure	Study design and appraisal score	Effect
Afshar et al (2007)[13]	1998–2004	Iran	156	LMs	Hospital-based case series; QDS 100%	Injuries or mortalities
Andersson et al (1995)[14]	May, 1994, to March, 1995	Afghanistan, Bosnia, Cambodia, Mozambique	174 489 people in 32 904 households	LMs	Sentinel community surveillance; MM 50%; absence of explanation of qualitative methods; data collected through focus groups but no explanation of data analysis, researcher influence, or how quantitative and qualitative methods were integrated	Injuries or mortalities, displaced populations, medical costs, and food security
Arcand et al (2015)[15]	Household surveys 1999–2001; landmine effect survey 2004–07	Angola	2712 households; 6252 households	LMs	Cross-sectional trending; QNR 100%	Socioeconomic
Asadollahi et al (2010)[16]	2007–08	Iran	137 injured by LMs and 360 not injured by LMs	LMs	Cross-sectional; QNR 75%; difference in sex proportions between two groups	Psychological and injuries or mortalities
Bendinelli (2009)[17]	November, 2003 to January, 2006	Cambodia	356	LMs and UXO	Hospital-based case series; QDS 100%	Injuries or mortalities
Berman and Reina (2014)[18]	1979–2013	Global	Unspecified	AXO	Grey literature	Injuries or mortalities
Bilukha et al (2011)[19]	July, 2006, to June, 2010	Nepal	307	LMs and UXO	Active prospective community surveillance; QDS 100%	Injuries or mortalities
Bilukha et al (2007)[20]	1994 to 2005	Chechnya	3021	LMs and UXO	Retrospective and prospective community surveillance, population based; QNR 100%	Injuries or mortalities
Bilukha and Brennan (2005)[21]	January, 1997, to September, 2002	Afghanistan	6114	LMs and UXO	Clinic-based and community-based surveillance; QDS 75%; data sensitivity estimated to be less than 50%	Injuries or mortalities
Bilukha et al (2003)[22]	March, 2001, to June, 2002	Afghanistan	1636	LMs and UXO	Clinic-based surveillance; QDS 75%; sample not considered representative	Injuries or mortalities
Boissiere et al (2011)[23]	2005–06	Vietnam	19 households (and other unspecified)	UXO	MM 75%; sample size and technique unspecified	Injuries or mortalities
Cameron et al (2010)[24]	November, 2004	Cambodia	440	LMs	Cost-benefit population-based; QNR 100%	Socioeconomic
Can et al (2009)[25]	2001–08	Turkey	23	LMs	Hospital-based case series; QDS 75%; sampling strategy unclear	Injuries or mortalities
Darwish et al (2009)[26]	2006	Lebanon	1500 ha	UXO	Cross-sectional trending; QNR 100%	Food security
Elliot and Harris (2001)[27]	2000–10 (projected)	Mozambique	130	LMs	Cost-benefit analysis; QNR 100%	Medical costs and socioeconomic
Fares and Fares (2013)[28]	September, 2006, to August, 2012	Lebanon	407	UXO	Hospital-based case series; QDS 25%; no sampling strategy, unclear whether representative of population being studied, unclear variables, and absence of standardised instruments	Injuries or mortalities
Fares et al (2014)[29]	August, 2006, to February, 2013	Lebanon	29	UXO	Hospital-based case series; QDS 75%; diagnostic tools unclear	Psychological and injuries or mortalities
Fares et al (2013)[30]	August, 2006, to December, 2011	Lebanon	122	UXO	Hospital-based case series; QDS 75%; unclear if population is representative	Injuries or mortalities
Gibson et al (2007)[31]	2003	Thailand	180 households	LMs	Cost-benefit analysis; QNR 100%	Socioeconomic
Gunaratnam et al (2003)[32]	June to September, 1998	Sri Lanka	67	LMs	QDS 50%; no sampling procedure and unclear if sample is representative	Psychological and injuries or mortalities
Hanevik and Kvale (2000)[33]	June 1991, to March, 1995	Eritrea	248	LMs	Retrospective population based; QNR 75%; potential selection bias as hospital based	Injuries or mortalities
Harris (2002)[34]	1999–2008 (projected)	Afghanistan	Unspecified	LMs	Cost-benefit analysis; QNR 100%	Medical costs and socioeconomic
Harris (2000)[35]	2000–2024 (projected)	Cambodia	Unspecified	LMs	Cost-benefit analysis; QNR 100%	Socioeconomic
Heshmati and Khayyat (2015)[36]	1960–2005	Kurdistan	12 863	LMs	QDS 100%	Injuries or mortalities
Human Rights Watch (2003)[37]	2003	Iraq	Unspecified	AXO	Grey literature	Socioeconomic
Husum et al (2002)[38]	1999	Cambodia and Kurdistan	57	LMs	Cross-sectional; QNR 75%; little information about sampling strategy	Injuries or mortalities
Docherty et al (2012)[39]	2012	Libya	Unspecified	AXO	Grey literature	Socioeconomic
Jackson (1996)[40]	January to September, 1994	Cambodia	453	LMs	Hospital-based case series; QDS 100%	Injuries or mortalities
Jacobs (1991)[41]	1978–80	Namibia	54	LMs	Hospital-based case series; QDS 100%	Injuries or mortalities
Jaha et al (2012)[42]	January, 2001, to December, 2010	Kosovo	120	LMs	Hospital-based case series; QDS 100%	Injuries or mortalities

(Table 2 continues on next page)

	Monitoring period	Setting	Sample size	Exposure	Study design and appraisal score	Effect
(Continued from previous page)						
Jahunlu et al (2002)[43]	1989–99	Iran	1082	LMs	QDS 100%	Injuries or mortalities
Lee et al (2006)[44]	April to June, 2002; September to November, 2003	Burma	1290	LMs	Retrospective longitudinal; QNR 100%	Injuries or mortalities
Lopes Cardozo et al (2004)[45]	2001	Burma	495	LMs	QDS 100%	Displaced populations
Meade and Mirocha (2000)[46]	May, 1996, to December, 1997	Sri Lanka	328	LMs	Hospital-based case series; QDS 100%	Injuries or mortalities
Merrouche (2011)[47]	1970–88	Cambodia	6703	LMs	Cross-sectional trending; QNR 100%	Socioeconomic
Merrouche (2008)[48]	1996–97	Mozambique	8250 households	LMs	Cross-sectional trending; QNR 100%	Socioeconomic
Mitchell (2004)[49]	Unspecified	Bosnia	17 interviewees and unspecified	LMs	MM 50%; absence of information about both qualitative and quantitative data collection methods	Displaced populations, medical costs, and socioeconomic
Mohamadzadeh et al (2012)[50]	1991–2005	Iran	300	LMs	QDS 75%; sampling strategy unclear	Injuries or mortalities
Morikawa et al (1998)[51]	Unspecified	Laos	397 children and 473 adults	UXO	Retrospective population based; QNR 75%; sampling strategy unclear	Injuries or mortalities
Mullany et al (2007)[52]	2004	Burma	1834 households	LMs	Cross-sectional; QNR 100%	Displaced populations
Necmioglu et al (2004)[53]	1993–2001	Turkey	186	LMs	Hospital-based case series; QDS 100%	Injuries or mortalities
Paterson et al (2013)[54]	2010–11	Afghanistan	25 villages	LMs and UXO	MM 100%	Socioeconomic
Phathammavong et al (2008)[55]	February, 2006 (1973–2005)	Laos	45	UXO	QDS 100%	Injuries or mortalities
Phung et al (2012)[56]	1975–2009	Vietnam	7030	LMs and UXO	Retrospective population based; QNR 100%	Injuries or mortalities
Saghafinia et al (2009)[57]	2002–05	Iran	288	LMs	QNR 75%; very little information about control group	Injuries or mortalities
Shabila et al (2010)[58]	July, 1998, to July, 2007	Iraq	285	LMs	Hospital-based case series; QDS 75%; sampling strategy unclear	Injuries or mortalities
Soroush et al (2010)[59]	August, 1988, to March, 2003	Iran	252	LMs	Hospital-based case series; QDS 100%	Injuries or mortalities
Soroush et al (2010)[60]	August, 1988, to March, 2003	Iran	3713	LMs	QDS 75%; unclear if sample is representative	Injuries or mortalities
Soroush et al. (2008)[61]	August, 1988, to March, 2003	Iran	1499	LMs and UXO	Hospital-based case series; QDS 100%	Injuries or mortalities
Southivong et al (2013)[62]	2011	Laos	190 injured and 380 non-injured	LMs and UXO	Cross-sectional; QNR 100%	Psychological and injuries or mortalities
Surrency et al (2007)[63]	May, 1996, to July, 1998	Afghanistan	571	LMs and UXO	Clinic-based and community-based surveillance; QDS 100%	Injuries or mortalities
Tracey (2011)[64]	1998 to 2011	Africa	Unspecified	AXO	Grey literature	Injuries or mortalities
Wolff et al (2007)[65]	June, 1998, to November, 2000	Iraq	32	LMs and UXO	Hospital-based case series; QDS 100%	Injuries or mortalities
Wyper (2012)[66]	Unspecified	Laos	51	LMs and UXO	Cross-sectional; QNR 50%; no sampling strategy and difference in sex proportions between the two groups	Psychological

LM=landmine. QDS=quantitative descriptive. MM=mixed methods. QNR=quantitative non-randomised. UXO=unexploded ordnance. AXO=abandoned explosive ordnance.

Table 2: **Description of the included studies, including study quality**

than 16 years of age (between 28·2% and 45·9% of casualties; appendix p 9).

19·5–82·6% of landmine or UXO victims had one or more limbs amputated (appendix p 10).[13,14,16,17,20,25,28,33,46,50,53,58–60,62,63,65] Landmines resulted in more amputations from the hip to the foot than did UXO (21·7% caused by landmines *vs* 5·5% caused by UXO in one study;[65] 29·2% *vs* 8·1% in another[63]), whereas UXO caused more amputations relating to the arms, upper body, and head than did landmines (27·8% caused by UXO *vs* 8·7% caused by landmines in one study;[65] 22·1% *vs* 6·5% in another[63]). Children were more likely to be injured by UXO than were adults in five studies.[17,19,20,22,63] When comparing child and adult casualties, children sustained more injuries to the arms, upper body, and head than did adults.[19,20]

Prevalence of pain in landmine or UXO victims was 37·3–100% (appendix p 11).[30,32,38] In one study,[38] the family income for 85% of landmine victims had declined and the main reasons given were chronic pain, feeling weak, and medical costs. Landmines were responsible for the largest proportion of bilateral blindness due to trauma (82·3%) in a study from Cambodia.[40] The prevalence of bilateral blindness in

	Study type	Setting	Sample	Exposure	Outcome
Fares et al (2014)[29]	Hospital-based case series; QDS	Lebanon	29; head and facial injuries	UXO	100% post-traumatic stress disorder prevalence; 79% anxiety prevalence; 72% depression prevalence
Fares et al (2013)[30]	Hospital based case series; QDS	Lebanon	112; younger than 18 years of age	UXO	Post-traumatic stress disorder prevalence: 73·0% overall, 76·7% adolescents, and 43·6% children
Gunaratnam et al (2003)[32]	QDS	Sri Lanka	67	LMs	Post-traumatic stress disorder: 68% male prevalence and 93% female prevalence; anxiety: 80% male prevalence and 80% female prevalence; depression: 71% male prevalence and 80% female prevalence
Southivong et al (2013)[62]	Cross-sectional; QNR	Laos	190 injured; 380 non-injured	LMs and UXO	Post-traumatic stress disorder prevalence: 10% in injured group versus 4% in non-injured group; women higher mean post-traumatic stress disorder score than men
Asadollahi et al (2010)[16]	Cross-sectional; QNR	Iran	137 injured; 360 not injured	LMs	Injured group prevalence: anxiety 77·4%; depression 79·6%; 69·3% scored high for both
Wyper (2012)[66]	Cross-sectional; QNR	Laos	51; control group size unclear	LMs and UXO	82% of those with a disability caused by LMs or UXO reported anxiety or depression versus 79% of those with a disability not caused by LMs or UXO

QDS=quantitative descriptive. UXO=unexploded ordnance. LM=landmine. QNR=quantitative non-randomised.

Table 3: **Psychological effects**

	Study type	Setting	Exposure	Sample size	Economically productive activities (%)	Playing (%)	Handling or tampering with explosive (%)	Standing nearby or watching (%)	Travelling (%)	Collecting wood or food or water or grass or metal (%)	Other or unknown (%)
Bilukha et al (2003)[22]	QDS	Afghanistan	LMs and UXO	1636	23·7%	13·5%	6%	..	11·4%	9·7%	21·8%
Bilukha et al (2007)[20]	QNR	Chechnya	LMs and UXO	3021	27·2%	5·5%	10·5%	24·7%	4·3%	1·9%	14·1%
Bilukha et al (2011)[19]	QDS	Nepal	LMs and UXO	307	..	..	49·5%	28·3%	3·6%	4·6%	14%
Can et al (2009)[25]	Hospital-based case series; QDS	Turkey	LMs and UXO	23	30·4%	21·7%	13%	8·7%	..	17·4%	8·7%
Heshmati and Khayyat (2015)[36]	QDS	Kurdistan	LMs	12 863	..	..	31%	..	27%	26%	16%
Mohamadzadeh et al (2012)[50]	QDS	Iran	LMs	300	27·7%	..	..	..	..	19·7%	..
Phung et al (2012)[56]	QNR	Vietnam	LMs and UXO	7030	46·9%	..	6·3%	..	..	11·2%	..
Soroush et al (2008)[61]	Hospital-based case series; QDS	Iran	LMs and UXO	1499	37·7%	4·5%	7·9%	..	..	..	..
Soroush et al (2010)[60]	QDS	Iran	LMs and UXO	3713	35%	..	2%	..	..	..	11%
Surrency et al (2007)[63]	QDS	Afghanistan	LMs and UXO	571	3·5%	14·2%	16·5%	5·1%	8·2%	34·9%	17·7%

QDS=quantitative descriptive. LM=landmine. UXO=unexploded ordnance. QNR=quantitative non-randomised.

Table 4: **Activities at time of injury**

landmine or UXO victims was 1·1–13% (appendix p 11).[14,17,25,50,58,63]

Landmines had a negative effect on internally displaced populations and returning refugees in five countries (table 5).[14,45,49,52] Results from cost-benefit studies of landmine clearance were variable and largely dependent on the value assigned to death and injury. Two studies[27,35] reported a negative net present value and four[24,31,34,48] reported a positive net present value (appendix p 12). A Bosnian study[49] estimated future costs from remaining landmines at US$36 million, but concluded that mine clearance was not a postconflict development priority for the country. In Afghanistan, demining was beneficial for physical security, economic productivity, and social amenities, although men benefited much more than women did.[54] In Angola, a causal relationship was identified between landmines and child health; landmine presence lowered height-for-age and weight-for-age.[15] In Cambodia, landmine contamination led to a loss of 0·5–1 year of child educational attainment, a large setback given that the sampled population averaged 4·5 years of education.[47] Across four countries—Afghanistan, Bosnia, Cambodia, and Mozambique—households with a mine victim were 40% more likely to report difficulty providing food for their family (odds ratio 1·4 [95% CI 1·2–1·6]).[14] In the same study, 61% of Cambodian landmine victims went into debt to pay for medical costs, whereas 12% had to sell assets; in Afghanistan, 85% went into debt and 60% had to sell assets. The authors of a Lebanese study[26] calculated direct and indirect losses to agriculture from UXO contamination in one of the most war-affected regions of the country. They modelled a number of study scenarios using 1 ha of agricultural land as a representative area. The direct to indirect loss ratio was calculated at 1:4 when 50% of land is inaccessible for 5 years and 1:7

	Study type	Setting	Sample size	Exposure	Outcome
Andersson et al (1995)[14]	MM	Afghanistan	1265	LMs	7% forcibly displaced because of landmines
Andersson et al (1995)[14]	MM	Cambodia	443	LMs	22% forcibly displaced because of landmines
Andersson et al (1995)[14]	MM	Mozambique	197	LMs	2% forcibly displaced because of landmines
Mitchell (2004)[49]	MM	Bosnia	Unspecified	LMs	4·4 million displaced during the Bosnian war; 38 landmine accidents per month once people began to return home after the conflict
Mullany et al (2007)[52]	Cross-sectional; QNR	Burma	1834 households	LMs	Increased odds of landmine injury because of: forcible displacement (odds ratio 3·89); food supply stolen or destroyed (odds ratio 4·55); multiple human rights violations (odds ratio 19·80)
Lopes Cardozo et al (2004)[45]	QDS	Burma	495 internally displaced Karenni refugees	LMs	Landmine injuries and threat of landmine injuries one of 31 psychosocial risk factors for mental illness

MM=mixed methods. LM=landmine. QNR=quantitative non-randomised. QDS=quantitiative descriptive.

Table 5: **Internally displaced populations and returning refugees**

when 50% of land is inaccessible for 10 years. This finding means that indirect losses represent four-fifths of total losses in the 5 year scenario and seven-eighths of total losses in the 10 year scenario; however, these losses are not usually included when the effects of war are measured.

To our knowledge, no academic studies have been published examining the effects of AXO, so we extracted data from four grey literature studies.[18,37,39,64] Global estimations of AXO explosions are contained within a comprehensive report[18] of unplanned explosions at munitions sites. The average number of casualties per year due to unplanned explosions at munitions sites has increased over time (1990s: 339 casualties per year; 2000s: 1333 casualties per year; 2010s: 1880 casualties per year). However, we cannot establish from these data what proportion was due to AXO. A report[64] of ineffective weapons stockpile management across Africa recorded 27 explosions in ammunition depots between 1998 and 2011 causing a minimum of 1831 fatalities and 1001 injuries. Two additional studies focused on AXO in Libya[39] and Iraq.[37] The authors of the Libya study[39] estimated that since 2011, thousands of tonnes of AXO have been left in hundreds of unsecured bunkers across Libya. They identified five major humanitarian threats posed by AXO: poor stockpile management practices in populated areas increase explosion risk; people, particularly children, visit AXO sites out of curiosity about weapons; civilians harvest materials from AXO for sale or personal use; community members clear AXO without professional training; and communities display live AXO in their own commemorative war museums. In Iraq, large stockpiles of AXO have been encountered in or near populated areas since 2003.[37] Iraqis loot AXO sites for parts and propellant to use or sell, increasing the likelihood of these munitions detonating. Children who scavenge for fuel from AXO or play among munitions and propellant are particularly at risk.

Discussion

The direct psychological effects of landmines or UXO appear high, with comorbidity and sex disparity present. The prevalence of post-traumatic stress disorder, anxiety, and depression from the included studies is not generalisable and we cannot establish causality. The findings indicate that further research is necessary to understand the scale of the problem. The downward trend of mortality and injury rates from landmines or UXO reflects global casualty data for ERW victims.[2] The high prevalence of injuries and mortalities among economically active men is in line with findings from previous systematic reviews.[6,8] That scrap metal collection from landmine-contaminated or UXO-contaminated sites is income dependent and that UXO is more likely be handled in these sites than are landmines is pertinent for mine risk education,[67] particularly if the victim was injured handling a device that they knew was an explosive. The divergence between the highest and lowest case fatality ratios for those injured by landmines or UXO suggests that the results are localised, with factors such as ordnance type and concentration, time since conflict end, and accessibility of health care all playing a part. Of the 21 studies that calculated case fatality ratios, nine[13,17,28,41,46,53,58,59,65] were hospital based so were likely to be underestimates as prehospital fatalities were excluded. Prehospital fatality ratios have been estimated at between 35% and 50%,[14,68] so casualty estimates from all 15 hospital-based studies could therefore be too low.

A worrying finding is the number of children injured and killed by landmines or UXO, a finding in line with a previous systematic review.[6] Injury type is dependent on the type of ordnance causing the injury: landmines cause more injuries to the lower body and UXO cause more injuries to the upper body. Reverberating effects of landmines or UXO were wide ranging and included negative effects on internally displaced populations, physical security, economic productivity, child health and educational attainment, food security, and agriculture.

Munitions and explosive residues and their break-down products also have long-term health and environmental effects that remain largely unexplored.[69,70]

Although individually these findings are not new, taken together they broaden the scope of understanding beyond the physical effects on victims and provide impetus for policy recognising the breadth of effects of landmine or UXO contamination. To our knowledge, no academic studies have been published examining the effects of AXO and AXO locations have not been systematically mapped globally, although the grey literature clearly shows that AXO is a substantial problem and further research is necessary.

From a public health perspective, mine clearance has important synergistic gains, not only in the reduction of morbidity and mortality, but also in improved socioeconomic outcomes for affected communities. The costs and benefits of landmine or UXO clearance depend on the measures used and the context. Value-of-life estimates mark a shift away from conventional valuing of death and injury in terms of the value of an individual's lost earnings, now considered to greatly underestimate the value of life.[24,71] The most comprehensive measures of cost benefit are those that use value-of-life estimates and measure the effect of landmine or UXO clearance on child health, child educational attainment, sustainable livelihoods, socioeconomic development, and agriculture. An improved understanding of the physical and psychological effects of injury from landmines or UXO also has important implications for health-care policy.

Limited access to and availability of health-care services impede child and adult survival rates.[72–75] Postinjury care is needed when the injury occurs and for the rest of the survivors' lives, and victims go into debt or sell assets to meet these costs. Without access to the rehabilitation that they require, disabled victims can become entrenched in a cycle of poverty. In low-income countries, rehabilitation services are rarely prioritised as primary health care understandably takes precedence.[76–78] More research is required than has been done so far to assess health-care service provision models in LMICs. For public health practitioners doing surveillance and assessment of an at-risk population's health and wellbeing, understanding context is key. Community-based and clinic-based surveillance methods used by the included studies can prove useful for enhancing public health surveillance systems in LMICs emerging from conflict. These systems have applications for the conflicts in Syria, Iraq, and Yemen and for developing understanding of the public health effects of explosive weapons in populated areas[79,80] and of toxic remnants of war.[69,70]

The included studies are heterogeneous in methodological approach. The 26 descriptive studies lack a control group or robust study design, so firm conclusions cannot be drawn. The sampling method used in the 16 hospital-based descriptive studies means that results cannot be credibly generalised to the target populations. They lack data for the population size of the hospital's catchment area and only include victims receiving treatment at that medical facility. Sample sizes from hospital-based studies were generally small (23–453). For the 50 peer-reviewed studies, samples are unlikely to be representative because of difficulties with access in countries emerging from conflict and collection of data from certain sectors of the population, such as nomads. Data collected retrospectively are liable to recall bias and self-reported data are liable to reporting bias. The decision to exclude studies with more than 20% military personnel underestimates the magnitude of ERW effects.

The direct physical and psychological effects of ERW depend on factors such as sex, age, ERW device type, availability and cost of health-care services, and extent of contamination and are exacerbated by the social, economic, and environmental conditions of the affected population. These effects provide a continuing evidence base for policy and action, but major research gaps exist, such as the effect of AXO on health. International support for mine action is declining. In 2015, donors and affected states contributed approximately $471·3 million in international and national support for mine action, the lowest amount since 2005.[2] Policy is often driven by perception of risk rather than reality and in this funding climate, the mine action community needs to accurately represent the effect of ERW on communities.

Contributors
AF and RS designed the study. AF did the systematic review and wrote the first draft. RS, CK, DH, and WZ reviewed and provided input into the manuscript. PB and PA contributed to writing of the manuscript.

Declaration of interests
We declare no competing interests.

Acknowledgments
This study was funded by King's College London. The authors would like to thank Paula Baraitser and Sharmani Barnard for their help and guidance and Martin Bjerregaard for their comments on the manuscript.

References

1 Duttine A, Hottentot E. Landmines and explosive remnants of war: a health threat not to be ignored. *Bull World Health Organ* 2013; **91:** 160–60A.
2 International Campaign to Ban Landmines. Landmine Monitor 2016. Geneva: International Campaign to Ban Landmines—Cluster Munition Coalition, 2016.
3 Parikh SM. Cluster munitions: a threat to health and human rights. *Med Confl Surviv* 2010; **26:** 101–07.
4 International Campaign to Ban Land Mines. The Treaty. http://www.icbl.org/en-gb/the-treaty.aspx (accessed Jan 17, 2016).
5 Krug EG, Ikeda RM, Qualls ML, Anderson M, Rosenberg ML, Jackson RJ. Preventing land mine related injury and disability: a public health perspective. *JAMA* 1998; **280:** 465–66.
6 Durham J, Hoy D. Burden of injury from explosive remnants of conflict in Lao PDR and Cambodia. *Asia Pac J Public Heal*th 2013; **25:** 124–33.
7 Salamati P, Razavi SM, Shokraneh F, et al. Mortality and injuries among Iranians in Iraq-Iran War: a systematic review. *Arch Iran Med* 2013 **16:** 542–50.
8 Nasir K, Hyder AA, Shahbaz CM. Injuries among Afghan refugees: review of evidence. *Prehosp Disaster Med* 2004·**19:** 169–73.
9 Bolton M. Foreign aid and landmine clearance. Governance, politics and security in Afghanistan, Bosnia and Sudan. London: I.B. Tauris, 2010.

For the **Information Management System for Mine Action** see http://mwiki.gichd.org/IM/Main_Page

10 Pluye P, Gagnon MP, Griffiths F, Johnson-Lafleur J. A scoring system for appraising mixed methods research, and concomitantly appraising qualitative, quantitative and mixed methods primary studies in mixed studies reviews. *Int J Nurs Stud* 2009; **46:** 529–46.

11 Pluye P, Robert E, Cargo M, et al. Proposal: a mixed methods appraisal tool for systematic mixed studies reviews. 2011. http://mixedmethodsappraisaltoolpublic.pbworks.com (accessed Aug 15, 2015).

12 Popay J, Roberts H, Sowden A, et al. Guidance on the conduct of narrative synthesis in systematic reviews. A Product from the ESRC Methods Programme. https://www.researchgate.net/profile/Lisa_Arai/publication/242311393_Guidance_on_the_conduct_of_narrative_synthesis_in_systematic_reviews_a_comparison_of_guidance-led_narrative_synthesis_versus_meta-analysis/links/5532159f0cf2f2a588ad67fd.pdf (accessed Aug 15, 2015).

13 Afshar A, Afshar N, Mirzatoloei F. Injuries due to landmine blast referred to Shahid Motahhary Hospital, Iran. *Med J Armed Forces India* 2007; **63:** 157–59.

14 Andersson N, da Sousa CP, Paredes S. Social cost of land mines in four countries: Afghanistan, Bosnia, Cambodia, and Mozambique. *BMJ* 1995; **311:** 718–21.

15 Arcand JL, Rodella AS, Rieger M. The impact of land mines on child health: evidence from Angola. *Econ Dev Cult Change* 2015; **63:** 249–79.

16 Asadollahi R, Saghafinia M, Nafissi N, Montazeri A, Asadollahi M, Khatami M. Anxiety, depression and health-related quality of life in those injured by landmines, Ilam, Islamic Republic of Iran. *East Mediterr Health J* 2010; **16:** 1108–14.

17 Bendinelli C. Effects of land mines and unexploded ordnance on the pediatric population and comparison with adults in rural Cambodia. *World J Surg* 2009; **33:** 1070–74.

18 Berman EG, Reina P. Unplanned explosions at munitions sites (UEMS). Excess stockpiles as liabilities rather than assets. Geneva: Small Arms Survey, 2014.

19 Bilukha OO, Laurenge H, Danee L, Subedi KP, Becknell K. Injuries and deaths due to victim-activated improvised explosive devices, landmines and other explosive remnants of war in Nepal. *Inj Prev* 2011; **17:** 326–31.

20 Bilukha OO, Brennan M, Anderson M, Tsitsaev Z, Murtazaeva E, Ibragimov R. Seen but not heard: injuries and deaths from landmines and unexploded ordnance in Chechnya, 1994–2005. *Prehosp Disaster Med* 2007; **22:** 507–12.

21 Bilukha OO, Brennan M. Injuries and deaths caused by unexploded ordnance in Afghanistan: review of surveillance data, 1997–2002. *Br Med J* 2005; **330:** 127–28.

22 Bilukha OO, Brennan M, Woodruff BA. Death and injury from landmines and unexploded ordnance in Afghanistan. *JAMA* 2003; **290:** 650–53.

23 Boissiere M, Sheil D, Basuki I. A booming trade? How collection of war residues affects livelihoods and forest in Vietnam. *Int Forestry Rev* 2011; **13:** 404–15.

24 Cameron M, Gibson J, Helmers K, Lim S, Tressler J, Vaddanak K. The value of statistical life and cost-benefit evaluations of landmine clearance in Cambodia. *Environ Dev Econ* 2010; **15:** 395–416.

25 Can M, Yildirimcan H, Ozkalipci O, et al. Landmine associated injuries in children in Turkey. *J Forensic Leg Med* 2009; **16:** 464–68.

26 Darwish R, Farajalla N, Masri R. The 2006 war and its inter-temporal economic impact on agriculture in Lebanon. *Disasters* 2009; **33:** 629–44.

27 Elliot G, Harris G. A cost-benefit analysis of landmine clearance in Mozambique. *Dev South Africa* 2001; **18:** 625–33.

28 Fares Y, Fares J. Anatomical and neuropsychological effects of cluster munitions. *Neurol Sci* 2013; **34:** 2095–100.

29 Fares Y, Fares J, Gebeily S. Head and facial injuries due to cluster munitions. *Neurol Sci* 2014; **35:** 905–10.

30 Fares Y, Ayoub F, Fares J, Khazim R, Khazim M, Gebeily S. Pain and neurological sequelae of cluster munitions on children and adolescents in south Lebanon. *Neurol Sci* 2013; **34:** 1971–76.

31 Gibson J, Barns S, Cameron M, Lim S, Scrimgeour F, Tressler J. The value of statistical life and the economics of landmine clearance in developing countries. *World Dev* 2007; **35:** 512–31.

32 Gunaratnam HR, Gunaratnam S, Somasundaram DJ. The psychosocial effects of landmines in Jaffna. *Med Confl Surviv* 2003; **19:** 223–34.

33 Hanevik K, Kvale G. Landmine injuries in Eritrea. *Br Med J* 2000; **321:** 1189.

34 Harris G. The economics of landmine clearance in Afghanistan. *Disasters* 2002; **26:** 49–54.

35 Harris G. The economics of landmine clearance: case study of Cambodia. *J Int Dev* 2000; **12:** 219.

36 Heshmati A, Khayyat NT. Analysis of landmine fatalities and injuries in the Kurdistan Region. *J Interpers Violence* 2015; **30:** 2591–615.

37 Human Rights Watch. Off Target. The conduct of the war and civilian casualties in Iraq. New York: Human Rights Watch, 2003: 117–26.

38 Husum H, Resell K, Vorren G, et al. Chronic pain in land mine accident survivors in Cambodia and Kurdistan. *Soc Sci Med* 2002; **55:** 1813–16.

39 Docherty B, Crowe A, Boehland N, Richards R. Explosive situation: Qaddafi's abandoned weapons and the threat to Libya's civilians. Cambridge: International Human Rights Clinic, 2012.

40 Jackson H. Bilateral blindness due to trauma in Cambodia. *Eye (Lond)* 1996; **10** (pt 4)**:** 517–20.

41 Jacobs LG. The landmine foot: its description and management. *Injury* 1991; **22:** 463–66.

42 Jaha L, Andreevska T, Rudari H, Ademi B, Ismaili-Jaha V. A decade of civilian vascular trauma in Kosovo. *World J Emerg Surg* 2012; **7:** 24.

43 Jahunlu HR, Husum H, Wisborg T. Mortality in land-mine accidents in Iran. *Prehosp Disaster Med* 2002; **17:** 107–09.

44 Lee TJ, Mullany LC, Richards AK, Kuiper HK, Maung C, Beyrer C. Mortality rates in conflict zones in Karen, Karenni, and Mon states in eastern Burma. *Trop Med Int Health* 2006; **11:** 1119–27.

45 Lopes Cardozo B, Talley L, Burton A, et al. Karenni refugees living in Thai-Burmese border camps: traumatic experiences, mental health outcomes, and social functioning. *Soc Sci Med* 2004; **58:** 2637–44.

46 Meade P, Mirocha J. Civilian landmine injuries in Sri Lanka. *J Trauma* 2000; **48:** 735–39.

47 Merrouche O. The Long term educational cost of war: evidence from landmine contamination in Cambodia. *J Dev Stud* 2011; **47:** 399–416.

48 Merrouche O. Landmines and poverty: IV evidence from Mozambique. *Peace Econ Peace Sci Public Policy* 2008; **14:** 1–18.

49 Mitchell SK. Death, disability, displaced persons and development: the case of landmines in Bosnia and Herzegovina. *World Dev* 2004; **32:** 2105–20.

50 Mohamadzadeh H, Moballeghi J, Delpisheh A, Alizadeh K, Afkhamzadeh A. Landmine victims in Iran Kurdistan; demographic features and accident characteristics. *Pakistan J Med Sci* 2012; **28:** 139–42.

51 Morikawa M, Taylor S, Persons M. Deaths and injuries due to unexploded ordnance (UXO) in northern Lao PDR (Laos). *Injury* 1998; **29:** 301–04.

52 Mullany LC, Richards AK, Lee CI, et al. Population-based survey methods to quantify associations between human rights violations and health outcomes among internally displaced persons in eastern Burma. *J Epidemiol Community Health* 2007; **61:** 908–14.

53 Necmioglu S, Subasi M, Kayikci C, Young DB. Lower limb landmine injuries. *Prosthet Orthot Int* 2004; **28:** 37–43.

54 Paterson T, Pound B, Ziaee AQ. Landmines and livelihoods in Afghanistan: evaluating the benefits of mine action. *J Peacebuilding Dev* 2013; **8:** 73–90.

55 Phathammavong O, Boutta N, Xayamoungkhoun P, Kuroiwa C. UXO victims and health status of populations living in Xiengkhuang Province, Lao PDR: a household based survy. *Biosci Trends* 2008; **2:** 112–16.

56 Phung TK, Viet L, Husum H. The legacy of war: an epidemiological study of cluster weapon and land mine accidents in Quang Tri Province, Vietnam. *Southeast Asian J Trop Med Public Health* 2012; **43:** 1035–41.

57 Saghafinia M, Nafissi N, Asadollahi R. Effect of the rural rescue system on reducing the mortality rate of landmine victims: a prospective study in Ilam Province, Iran. *Prehosp Disaster Med* 2009; **24:** 126–29.

58 Shabila NP, Taha HI, Al-Hadithi TS. Landmine injuries at the Emergency Management Center in Erbil, Iraq. *Confl Health* 2010; **4:** 15.

59 Soroush AR, Flahati F, Zargar M, Soroush MR, Khateri S, Khaji A. Women pose innocent victims of landmines in postwar Iran. *Iran J Public Health* 2010; **39:** 32–35.

60 Soroush AR, Flahati F, Zargar M, et al. Injuries associated with landmines and unexploded ordnances in Iran. *Iran Red Crescent Med J* 2010; **12:** 384–87.

61 Soroush A, Falahati F, Zargar M, Soroush M, Khateri S, Khaji A. Amputations due to landmine and unexploded ordinances in post-war Iran. *Arch Iran Med* 2008; **11:** 595–97.

62 Southivong B, Ichikawa M, Nakahara S, Southivong C. A cross-sectional community study of post-traumatic stress disorder and social support in Lao People's Democratic Republic. *Bull World Health Organ* 2013; **91:** 765–72.

63 Surrency AB, Graitcer PL, Henderson AK. Key factors for civilian injuries and deaths from exploding landmines and ordnance. *Inj Prev* 2007; **13:** 197–201.

64 Tracey L. Ticking time bombs. Ineffective weapons stockpile management in Africa. Pretoria: Institute for Security Studies, 2011.

65 Wolff KS, Prusa AM, Bulwas S, et al. Cluster bomb vs. antipersonnel mine related injuries. An experience from the Kuwaiti-Iraqi border from June 1998 to November 2000. *Eur Surg* 2007; **39:** 111–17.

66 Wyper RB. An exploratory study of the perceived impact of health problems of landmine/UXO victims versus another disability group. *Health Qual Life Outcomes* 2012; **10:** 121.

67 Durham J, Mohammed A. Mine risk education in the Lao PDR: time for a public health approach to risk reduction? *Int J Health Promot Educ* **46:** 27–32.

68 Ascherio A, Biellik R, Epstein A, et al. Deaths and injuries caused by land mines in Mozambique. *Lancet* 1995; **346:** 721–24.

69 Pichtel J, Pichtel J. Distribution and fate of military explosives and propellants in soil: a review. *Appl Environ Soil Sci* 2012; **2012:** 1–33

70 Lima DR, Bezerra ML, Neves EB, Moreira FR. Impact of ammunition and military explosives on human health and the environment. *Rev Environ Health* 2011; **26:** 101–10.

71 Geneva International Centre for Humanitarian Demining. Priority-setting in mine action: values, criteria and indicators for priority-setting in mine action. Geneva: Geneva International Centre for Humanitarian Demining, 2011.

72 Richard AJ, Lee CI, Richard MG, Oo EK, Lee T, Stock L. Essential trauma management training: addressing service delivery needs in active conflict zones in eastern Myanmar. *Hum Resources Health* 2009; **7:** 19.

73 Wisborg T, Murad MK, Edvardsen O, Brinchmann BS. Life or death. The social impact of paramedics and first responders in landmine-infested villages in northern Iraq. *Rural Remote Health* 2008; **8:** 816.

74 Nia MS, Naffisi N, Mohebbi HA, Moharamzadeh Y. The role of performing life support courses in rural areas in improving pre-hospital physiologic conditions of patients with penetrating injuries. *J Coll Physicians Surg Pakistan* 2008; **18:** 538–41.

75 Van Heng Y, Davoung C, Husum H. Non-doctors as trauma surgeons? A controlled study of trauma training for non-graduate surgeons in Rural Cambodia. *Prehosp Disaster Med* 2008; **23:** 483–89.

76 Pupulin E. A personal view of prosthetics and orthotics. *Prosthet Orthot Int* 2001; **25:** 93–95.

77 Disability Rights Promotion International. Declaration on the Workshop on Monitoring the Rights of Persons with Disabilities in Africa, 24th January–2nd February 2011 in Kigali, Rwanda. http://www.yorku.ca/drpi/files/KigaliDeclaration2011.pdf (accessed Oct 11, 2016).

78 Peat M. Community based rehabilitation—development and structure: part 2. *Clin Rehabil* 1991; **5:** 231–39.

79 Wille C. The implications of the reverberating effects of explosive weapons use in populated areas for implementing the Sustainable Development Goals. Geneva: United Nations Institute for Disarmament Research, 2016.

80 International Committee of the Red Cross. Explosive weapons in populated areas. Humanitarian, legal, technical and military aspects. Geneva: International Committee of the Red Cross, 2015.